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## CHAPTER II

Preliminary Classification.	
Proposed Class:	Unknown
Subclass:	Unknown

**TRANSMITTAL LETTER  
TO THE UNITED STATES ELECTED OFFICE (EO/US)  
(ENTRY INTO U.S. NATIONAL PHASE UNDER CHAPTER II)**

PCT/EP00/09814	6 October 2000 (06.10.2000)	8 October 1999 (08.10.1999)
<b>International Application Number</b>	<b>International Filing Date</b>	<b>International Earliest Priority Date</b>

TITLE OF INVENTION: ELECTROMECHANICAL COMPONENT AND METHOD FOR PRODUCING THE SAME

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**ATTENTION: EO/US  
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1. Applicant herewith submits to the United States Elected Office (EO/US) the following items under 35 U.S.C. Section 371:
  - a. This express request to immediately begin national examination procedures (35 U.S.C. Section 371(f)).
  - b. The U.S. National Fee (35 U.S.C. Section 371(c)(1)) and other fees (37 C.F.R. Section 1.492) as indicated below:
2. This application qualifies for small entity status.

**CERTIFICATION UNDER 37 C.F.R. SECTION 1.10\***

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### 3. Fees

CLAIMS FEE*	(1) FOR	(2) NUMBER FILED	(3) NUMBER EXTRA	(4) RATE	(5) CALCULATIONS
	TOTAL CLAIMS	36 -20 =	16	x \$18.00 =	\$ 288.00
	INDEPENDENT CLAIMS	2 - 3 =	0	x \$84.00 =	\$ 0.00
	MULTIPLE DEPENDENT CLAIM(S) (if applicable) + \$280.00				\$ 0.00
BASIC FEE	U.S. PTO WAS NOT INTERNATIONAL PRELIMINARY EXAMINATION AUTHORITY Where no international preliminary examination fee as set forth in Section 1.482 has been paid to the U.S. PTO, and payment of an international search fee as set forth in Section 1.445(a)(2) to the U.S. PTO where a search report on the international application has been prepared by the European Patent Office or the Japanese Patent Office (37 C.F.R. Section 1.492(a)(5)) ..... \$890.00				\$ 890.00
	Total of above Calculations				= \$ 1178.00
SMALL ENTITY	Reduction by 1/2 for filing by small entity, if applicable. (note 37 CFR Sections 1.9, 1.27, 1.28)				- \$ 589.00
	Subtotal				\$ 589.00
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	Fee for recording the enclosed assignment document \$40.00 (37 C.F.R. Section 1.21(h)). See attached "ASSIGNMENT COVER SHEET".				\$ 0.00
TOTAL	Total Fees enclosed				\$ 589.00

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A duplicate copy of this sheet is enclosed.

4. A copy of the International application as filed (35 U.S.C. Section 371(c)(2)) is transmitted herewith.
5. A translation of the International application into the English language (35 U.S.C. Section 371(c)(2)) is transmitted herewith.
6. A copy of the International Examination Report (PCT/IPEA/409) is transmitted herewith.
7. Annexes to the International Preliminary Examination Report are transmitted herewith.
8. A translation of the annexes to the International Preliminary Examination Report is transmitted herewith.

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JG13 Rec'd PCT/PTO 04 APR 2002

9. An oath or declaration of the inventor (35 U.S.C. Section 371(c)(4)) complying with 35 U.S.C. Section 115 will follow.

Other document(s) or information included:

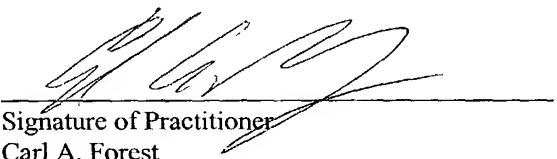
10. An International Search Report (PCT/ISA/210) is transmitted herewith.
11. An Information Disclosure Statement under 37 C.F.R. Sections 1.97 and 1.98 is transmitted herewith. Also transmitted herewith are Form PTO/SB/08A and copies of citations listed.
12. Additional documents:
- a. International Publication No. WO 01/27026 (cover sheet only)
  - b. First Preliminary Amendment (37 C.F.R. Section 1.121)
  - c. Annotated Copy Of Final Version Of PCT/EP00/09814
  - d. Notice Informing The Applicant Of The Communication Of The International Application To The Designated Offices
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13. The above items are being transmitted before 30 months from any claimed priority date.

#### AUTHORIZATION TO CHARGE ADDITIONAL FEES

The Commissioner is hereby authorized to charge the following additional fees that may be required by this paper and during the entire pendency of this application to Account No. 50-1848:

37 C.F.R. Section 1.492(a)(1), (2), (3), and (4) (filing fees)  
37 C.F.R. Section 1.492(b), (c), and (d) (presentation of extra claims)  
37 C.F.R. Section 1.17 (application processing fees)  
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ELECTROMECHANICAL COMPONENT AND METHOD FOR  
PRODUCING THE SAME

Field of the Invention

The present invention refers to microstructure technology and especially to electromechanical components.

Background of the Invention and Prior Art

Electromechanical components are components which electrically detect or electrically cause a mechanical effect. Examples of electromechanical components are sensors for linear accelerations, rotary speed sensors, force sensors, pressure sensors and also microvalves or micropumps.

Acceleration sensors, for example, i.e. sensors for detecting a linear acceleration, or rotary speed sensors for detecting an angular acceleration, normally include a movable mass which is connected to a fixed frame through at least one spring beam. When an acceleration sensor is subjected to an acceleration, the spring beam will deform elastically and the mass will be deflected. This deflection can then be detected making use of a large number of known methods, such a capacitive, inductive, optical etc. methods.

Microvalves, however, normally have a movable, elastic structure which, in response to the application of a suitable electric signal, will reduce or enlarge the size of a flow path for a fluid, i.e. which will cause as a mechanical effect a limitation of the amount of fluid flowing through.

Micropumps are, however, normally provided with a diaphragm which is elastic or elastically suspended so as to change a volume. A micropump will normally also be pro-

vided with valves so as to achieve via said change in volume a conveyance of a defined amount of fluid. It follows that the mechanical effect in the case of micropumps is transport and dosage of a fluid.

Pressure sensors or force sensors may also be provided with an elastically deformable diaphragm, which is elastically deformed, i.e. "deflected", to a certain degree in response to a specific pressure; just as in the case of the acceleration sensor, this deflection can be detected in various ways so as to obtain an electric signal indicative of the pressure applied. All the above-mentioned electromechanical components comprise an active part, which is elastically deformed by the outer mechanical effect or the elastic deformation of which leads to the mechanical effect.

Such electromechanical components can comprise an integrated means for converting the mechanical effect into an electric effect or for converting an electric effect into a mechanical effect. Only by way of example, the known finger structure should here be mentioned; this structure comprises a first group of fingers connected to a movable part, and a second group of fingers connected to a fixed part relative to which the movable part moves. The two groups of fingers are arranged in an interleaving mode of arrangement in such a way that a deflection of the movable part relative to the fixed part results in a change in the distances between the fingers, said change leading to a change in the capacitance of the finger arrangement. This change in capacitance is e.g. proportional to the acceleration acting on the movable part. In the case of a pressure sensor, the mechanical effect can be caused e.g. by a change in the distance between two planar electrodes in the sense of a plate capacitor. This change in capacitance can be measured making use of an alternating voltage.

Electromechanical components of this type are normally produced from silicon material in miniaturized form making use of the silicon-based technology which proved to be efficient in wafer processing. Silicon-based technology permits mass production which resulted in a wide range of use of e.g. capacitive acceleration sensors which have been produced using silicon-based technology; such acceleration sensors are in particular

One disadvantage of such systems is the fact that, due to the very small dimensions of their sensor structures, when e.g. finger structures are intended to be used, and in view of the so-called sticking effect, it is necessary to protect such sensors against particles and moisture by a virtually hermetic seal. Another disadvantage is that, in spite of batch production and the build-up technique used in the field of electronics technology, the manufacturing process in its entirety is still very expensive, since, in addition to the electronic chip, also two silicon wafers must be produced, connected and diced by micro-mechanical methods.

Although silicon-based technology has gained great acceptance, which resulted in more moderate prices for the whole clean room systems and which has already led to a high degree of automation, it should still be pointed out that a complete clean room as well as adequately trained staff are necessary for wafer processing. It follows that a decisive cost factor is not the material itself, but the production outlay, which is essentially determined by the systems required and the labour costs incurred.

DE 44 02 119 A1 discloses a micro-diaphragm pump, the diaphragm being produced from titanium and the valves from polyimide. Alternatively, the diaphragm may consist of polyimide having a heating coil applied thereto .

US patent No. 5,836,750 discloses an electrostatically driven mesopump comprising a plurality of unit cells. A pump diaphragm can be produced from metal-coated polymers, from metal or from a conductive flexible elastic polymer.

DE 197 20 482 A1 discloses a micro-diaphragm pump having a diaphragm which consists of PC or PFA. A piezo-actor can be provided on a brass sheet which is, in turn, applied to the pump diaphragm.

US patent No. 5,639,973 discloses an acceleration detector comprising a fixed substrate, a flexible substrate, a work body and a detector housing. The fixed substrate is implemented as a platelike substrate and connected to the detector housing on a peripheral portion thereof. A plateshaped fixed electrode is formed in a similar way. The flexible substrate is also implemented as a plateshaped substrate and connected to the detector housing on the peripheral portion thereof. The work body is attached to the flexible substrate and causes an elastic deflection of the flexible substrate when an acceleration is applied. The detector housing consist of metal or plastic material. The electrodes consist of metal. The flexible substrate consists of glass, ceramics or synthetic resin.

### Summary of the Invention

It is the object of the present invention to provide less expensive electromechanical components and methods for producing the same, which still have mechanical and electrical properties comparable to those of silicon components.

[This object is achieved by an electromechanical component according to claim 1 and by a method for producing an electromechanical component according to claim 21.]

In accordance with a first aspect of the present invention, this object is achieved by an electromechanical component comprising: a polymeric body including a mechanically active part and a frame; and a metal layer which covers the mechanically active part at least partially so as to mechanically stabilize the same, wherein an area of the polymeric body, which has the metal layer provided thereon, consists of a first polymer material which is adapted to be metallized in a wet-chemical process, and another area, which does not have a metal layer provided thereon, consists of a second polymer material which is not adapted to be metallized in a wet-chemical process.

In accordance with a second aspect of the present invention, this object is achieved by a method for producing an electromechanical component comprising the steps of: forming a polymeric body including a mechanically active part and a frame, the step of forming the polymeric body comprising the following steps in an arbitrary sequence: injection moulding a first portion of the polymeric body which is to be metallized, making use of a first polymer material which is adapted to be metallized in a wet-chemical process; injection moulding a second portion of the polymeric body which is not to be metallized, making use of a second polymer material which is not adapted to be metallized in a wet-chemical process; and forming a metal layer, which covers the mechanically active part at least partially so as to mechanically stabilize the same, by wet-chemical metallization in such a way that only the surfaces of the polymeric body consisting of the first polymer material are provided with a metal layer.

The present invention is based on the finding that for producing electromechanical components at a really moderate price, it will be necessary to take leave of the established silicon-based technology. In accordance with the present invention, a polymer



material is used as a starting material; making use of e.g. injection-moulding and/or embossing (stamping) technique(s), which has/have gained widespread acceptance as well, this polymer material can be processed such that almost arbitrary shapes and structures are obtained. In addition, polymer materials are normally very moderate in price. The decisive advantage, however, resides in the manufacturing technique. The machinery required for processing polymers is much less complicated and, consequently, much less expensive than the respective machinery used in the field of silicon-based technology. Depending on the respective composition, also polymer materials have elastic properties which can be used for producing spring beams having defined deflection properties.

Polymer materials are, however, problematic insofar as plastic materials of this kind have flow properties leading to serious problems with regard to the long-term stability, unless precautionary measures are taken. According to the present invention, this problem is solved in that mechanically active parts of the polymeric body of the electromechanical component are provided with a metal layer. A plastic/metal composite system is produced in this way, which can achieve properties that are almost as good as those of a component consisting completely of metal or of silicon. This is due to the fact that the outer metal surfaces have a stronger influence on the mechanical parameters, such as the stiffness and the areal moment of inertia, than the plastic core. For the metal layer itself, gold can be used by way of example. For reducing the costs still further, a metal layer consisting of nickel, copper etc. may, however, be used as well. The mechanically active parts of the acceleration sensor described are the spring beams through which the seismic mass is suspended from the fixed frame. In the case of electromechanical components having diaphragms, the mechanically active part also includes the diaphragm which is elastically deformable and which, due to the flow properties of the plastic material, would have an insufficient long-term stability if it were not provided with a metal layer.

In accordance with a particularly preferred embodiment, the electromechanical component consists of a two-component polymeric body comprising a first part consisting of a first polymer material which is adapted to be metallized in a wet-chemical process, and

a second part consisting of a second polymer material which is not adapted to be metallized in a wet-chemical process. The necessary metallizations can be defined in this way by a double-shot injection moulding process, i.e. the metallization of the mechanically active parts which serves to improve the mechanical stability of these parts and also the metallizations which are necessary for converting the mechanical effect into an electric signal, such as finger structures, capacitor plates, and also the necessary conducting tracks of the electromechanical component leading to an internal electronic circuit, which is inserted in or secured in position on the polymeric body in a hybrid way, or to an outer plug.

The essential advantage of the method according to the present invention is an extreme reduction of costs in comparison with electromechanical components which have been produced making use of silicon-based technology, a reduction of costs up to a factor of one thousand being expected.

The minimum structural sizes which can nowadays be achieved by processing plastic materials are, at least at present, still substantially larger than the sizes that can be achieved by silicon-based micromechanics. This will impair primarily the dimensions of the springs and the distances between capacitor electrodes. In order to minimize the electric noise of the sensor system, a minimum capacitance must be obtained; in the case of silicon-based technology this must be achieved through very small distances between the electrodes. In accordance with the method according to the present invention, however, this need not be purchased at the cost of an ever increasing miniaturization and the problems entailed thereby, but it can be obtained by increasing the physical sizes, since materials which are much less expensive than silicon are used and since the preferred injection moulding process does not involve any substantial limitations of the height of e.g. oscillating masses, whereas the use of polysilicon definitely leads to such limitations.

On the other hand, the moulding/machining technique using polymer materials has, as is generally known, also the potential for a production of structures which may also have sizes in the micrometer range. For this purpose, the injection moulding process is pref-

Last but not least, the production process comprises a small number of steps in comparison with silicon-based technology, whereby the reject rate in the production process and, consequently, also the costs can be kept low.

In the following, preferred embodiments of the present invention will be explained in detail making reference to the drawings enclosed, in which

Fig. 1 shows a schematic top view of the electromechanical component according to the present invention;

Fig. 2 shows a schematic side view of the electromechanical component having a housing base and a housing cover according to a preferred embodiment of the present invention;

Fig. 3 shows a side view of the electromechanical component in combination with an SMD component for electric activation and/or evaluation;

Fig. 4 shows a side view of the electromechanical component with spring contacts for contacting an electronic circuit;

Fig. 5 shows a side view of the electromechanical component with a spring and bumps for contacting an electronic circuit;

Fig. 6 shows a side view of the electromechanical component with adhesive bumps for contacting an electronic circuit; and

Fig. 7 shows a top view of a detail of the interleaving groups of electrodes according to Fig. 1, the electrode fingers having, however, a wavelike shape.

Fig. 1 shows an electromechanical component designated generally by reference numeral 10. The electromechanical component 10 is provided with a polymeric body 12 having a mechanically active component including the two spring beams 14a, 14b as well as a seismic mass 14c. The electromechanical component 10 shown in Fig. 1 is a sensor for measuring a mechanical acceleration. The acceleration sensor shown in Fig. 1 uses, by way of example, the capacitive detection principle comprising a finger struc-

ture including a first group of fingers 16a, which are attached to a fixed frame 18, and a second group of fingers 16b having fingers which are secured to the seismic mass 14c. The electromechanical component 10, which is shown in the form of an acceleration sensor in Fig. 1, additionally includes some kind of electronic circuit (chip) 20 as well as a connecting plug 22, which also represents part of the polymeric body 12, i.e. the connecting plug 22 and the fixed frame as well as the mechanically active part all consist of polymeric material. For activating and reading the finger structure 16a, 16b the electromechanical component additionally includes conducting tracks 24a to 24c connecting the movable mass as well as the two first groups of fingers 16a of the finger structures via bonding wires 26 to the chip, i.e. the respective connecting areas of the chip. The electromechanical component 10 additionally comprises further conducting tracks 28a to 28d which, on the one hand, are also connected to the chip 20 via bonding wires and which, on the other hand, terminate in ends of increased width so as to form with the polymeric body 12 a connecting plug having four contacts in the embodiment shown in Fig. 1.

When the electromechanical component 10 is subjected to linear acceleration, the seismic (inertial) mass 14c is deflected relative to the fixed frame 18, and this leads to an elastic deformation of the spring beams 14a, 14b. The displacement of the mass 14c leads to a changed capacitance which can be detected making use of the first and second groups of fingers 16a, 16b and which can already be processed "in situ" in the IC 20 so as to be outputted via the plug area 22.

As has already been mentioned, the long-term stability of such an electromechanical component would not be particularly high, since polymer materials normally have a flow behaviour which changes with time. In other words, the constant deformation of the two spring beams 14a, 14b will cause also a plastic deformation in addition to the elastic deformation in the course of time, whereby the sensor would lose sensitivity in the course of time and finally become useless. According to the present invention this problem is solved by providing a metal layer 30 covering, at least partially, the mechanically active part so as to mechanically stabilize the same. In the embodiment shown in Fig. 1, the mechanically active part comprises the springs 14a, 14b as well as the seismic

mass 14c. For obtaining the stabilization according to the present invention, i.e. so as to achieve a good long-term stability without which the use of polymer materials for such electromechanical components would not be possible at all, the spring beams are provided with the metal layer. It is, however, not absolutely necessary to metallize also the seismic mass 14c for reasons of mechanical stabilization. In the present case this is, however, done in view of the capacitive detection principle. If the detection principle used is not a capacitive principle, but some other kind of detection principle, which does not necessitate contacting of the movable mass 14c, it would suffice to metallize the spring beams 14a, 14b so as to decisively improve their mechanical properties.

A further advantage of the present invention is to be seen in the fact that the metallic layers, which are provided for the purpose of stabilization and which are preferably implemented such that they encompass the beams not only partially but fully, may simultaneously be used for conducting electric signals.

In principle, the polymeric body 12 may consist of only one polymer material; in this case, the patterning of the capacitive detection electrodes and of the spring beams would be carried out making use of e.g. a single-shot injection moulding process, whereupon the metallization pattern shown in Fig. 1, i.e. the metal layers on the mechanically active part used for the purpose of stabilization and the additional metal layers used for forming the conducting tracks, would be produced making use of a shadow mask.

It is, however, preferred to use a double-shot injection moulding process in which the areas which are to be metallized later on are produced in a first shot making use of a polymer material which is adapted to be metallized in a wet-chemical process, whereupon the fixed frame is injection moulded in a second shot around the result of the first shot. This two-component injection moulding technology is advantageous insofar as the patterning of the metallization is obtained so to speak automatically when the result of the second shot is metallized in a wet-chemical process, since a metal layer will only be formed on the surfaces consisting of the first polymer material, which is metallizable, whereas no deposition of metal will take place on the other surfaces consisting of the

second polymer material, which is not adapted to be metallized in a wet-chemical process.

The metallized part of the polymeric body adheres to the non-metallized part per se, due to the injection moulding process. In order to improve the connections, since mechanical forces may perhaps act on the polymeric body at least in the area of the springs, positive-locking anchoring means 32 are, however, preferably provided, which have the effect that the two polymeric parts made of the different polymer materials will not only adhere to one another, but will mechanically be interconnected in positive engagement with one another. Anchoring structures which are suitable for this purpose are anchoring structures of arbitrary shape which are compatible with the production process comprising at least two stages.

As can be seen in Fig. 1, the IC 20 need not be provided in the form of a housed chip, but it may also be provided in the form of a bare chip having suitable connecting areas which are adapted to be contacted via bonding wires 26.

In the following, the preferred production method, in which two different polymer materials for the two injection-moulding shots are used, will be discussed in detail. The springs 14a, 14b, the seismic mass 14c, the finger electrodes 16a, 16b and, firstly, the conducting track areas 24a to 24c as well as, secondly, the conducting track areas 28a to 28d extending into the plug area 22 are produced in the first shot from a suitable metallizable first polymer material, e.g. from Pd-doped LCP (LCP = Liquid Crystal Polymer) or from polyamide (PA) 66. The residual part of the fixed frame, the insulation areas and other features, such as the snap-type connector, which will be discussed making reference to Fig. 2, are, however, produced from the second polymer material in the second shot; in the subsequently employed metallization process, this second polymer material will not accept any metal. Such a material is e.g. undoped LCP or PA 66. As far as the structural design of the mould is concerned, it may perhaps also be advantageous to reverse the sequence in the injection moulding process, i.e. to injection-mould first the structures which are not to be metallized and then the structures which are to be metallized.

The two-component injection-moulded parts are then treated in a sequence of wet-chemical processing steps in such a way that a metal layer will autocatalytically deposit on the surface of the first polymer material. The most important operating steps consist of the steps of cleaning the injection-moulded parts, tempering the injection-moulded parts and sensitizing the surface thereof by a surface reaction, such as mild etching of the surface or causing the surface to swell and seeding it with Pd seeds.

Subsequently, the injection-moulded parts are coated with metal in an autocatalytic bath. Suitable materials for the layers are copper or nickel as start layer, conductor layer and layer used for the purpose of mechanical stabilization, and gold as a surface protection layer which is adapted to be soldered and wire-bonded. Typical metal layer thicknesses are thicknesses in the order of 30  $\mu\text{m}$ , the thickness being, however, limited by layer stresses and the adhesion of the layer to the polymer material and, of course, especially by the deposition period.

The layer thickness is therefore preferably increased by a galvanic layer, e.g. nickel, prior to the gold-plating step.

Whereas metal layers deposited without making use of external current are characterized by a very high conformity of the layers, galvanic layers with fine pattern details tend to have strongly inhomogeneous layer thicknesses which may have a negative effect on the geometry of the components, in particular on the distances between the finger electrodes or on the springs and their elastic properties.

Due to the symmetry of the structure, the fixed metallized areas in the form of the finger electrodes 16a can be used as auxiliary electrodes in accordance with a preferred production method of the present invention so as to achieve, by the application of a suitable potential, a more homogeneous deposition on the spring beams and also on the seismic mass. In the course of this process, metal does not deposit on the auxiliary electrode. For electrodeposition, electric contacting of the respective areas is necessary. When the voltage is being applied, an attractive force will act on the sensor struc-



ture, but, due to the symmetry of the structure in its entirety, this attractive force will be compensated for.

In order to reliably prevent the first group of fingers 16a and the second group of fingers 16b from coming into contact with one another when an electric voltage is being applied, and for unsymmetric structures in the case of which the attractive forces do not compensate each other, an auxiliary connection 34 consisting of the first or the second polymer material can be used. The auxiliary connection will then be removed, e.g. by punching out, after the end of the metallization process, when potential differences are no longer applied to the comb structure.

An additional parameter that has to be taken into account in the case of the preferred embodiment of the present invention in which the polymeric body consists of two polymer materials is the bonding strength between the various polymer materials. When two LCP materials are bonded in a two-component injection moulding process without any additional measures being taken, an adhesive strength is obtained which may be perhaps too low. The anchoring means 32, which have already been described, will therefore be used in order to improve the adhesive strength between the areas of different polymer materials; in particular, these anchoring means 32 are advantageously positioned such that they are located at the points where the highest mechanical loads occur, i.e. in the area where the springs are connected to the fixed frame.

After the production and the metallization of the injection-moulded part, the electromechanical component will be equipped with the electronic circuit 20. For electric contacting, various measures can be taken, which will be discussed in detail in the figures following hereinbelow.

Fig. 2 shows a side view of the electromechanical component 10; just as in Fig. 1, bond connections via bonding wires 26 were used for contacting the chip 20 in Fig. 2. For increasing the robustness, an encapsulating material 36 is applied on top of the area in which the chip 20 and the bonding wires 26 are located. Fig. 2 additionally shows how the external conducting tracks are implemented, taking the conducting track 28d in the



structuring the electromechanical component from three components, the sensor element is closed from only one side with a housing cover in accordance with a preferred embodiment, whereas the other side is already closed during the production process of the polymeric body. In other words, the housing base is formed simultaneously with the formation of the polymeric body; this can easily be achieved by a suitable mould.

The housing cover must, however, be implemented such that it can be attached subsequently so that the electromechanical component can be equipped with the chip 20. However, when an electromechanical component having already inserted therein a chip is dispensed with, i.e. when the connecting areas of the conducting tracks 24a to 24c (Fig. 1) are "extended" up to the plug area 22, it will, in principle, also be possible to form the whole electromechanical component at one go making use of a suitable mould, since, in contrast to the known silicon-based technologies, the surfaces to be metallized need not be accessible from above when the wet-chemical metallization process in a catalytic bath is used, since the autocatalytic bath enters the cavities and leads to a deposition of metal wherever the material which is adapted to have metal applied thereto making use of the wet-chemical process is present as a polymer material.

In order to provide a higher geometric accuracy of the mechanically active part of the polymeric body, i.e. of the spring beams 14a, 14b and of the movable mass 14c in the case of the acceleration sensor, an injection/embossing (injection/stamping) process or a hot-embossing (hot-stamping) process can be used instead of the injection moulding process; the resultant embossed (stamped) parts are then encompassed with polymer material by injection moulding so as to form the finished polymeric body in which the mechanically active part and, in cases in which capacitive evaluation is used, also the second group of fingers, i.e. the fixed fingers attached to the frame 18, have an even more precisely defined geometrical shape. Both the injection/embossing process and the hot embossing process permit a very high structural fineness and, in particular, little distortion of the individual elements; this distortion may occur due to orientation effects of the polymers when an injection moulding process alone is used.

Another advantageous variant of contacting the electric circuit, which is now again provided in the form of a bare chip 20, is shown in Fig. 4. In the case of this variant, the chip 20 is not contacted by soldering, glueing, bonding or the like, but only by spring force making use of metallized spring contacts 62. In order to obtain a simpler structural design of the spring contacts 62, a recess 64 is provided in the polymeric body 12 in the case of this embodiment of the present invention; this recess can easily be obtained when a suitable injection mould is used. Preferably, the recess is dimensioned such that the surface of the chip 20 is essentially flush with the surface of the polymeric body 12, as can be seen in Fig. 4. Subsequently, the chip is placed in the recess and, if necessary, slightly fixed in position so that it will not be displaced when the cover 42 is being attached. When the cover is being attached and when the cover and the polymeric body 12 are pressed together, the snap connectors 44 will snap into place sooner or later. The spring contacts 62 are dimensioned such that, when the snap connections 44 snap into place, they will apply pressure to the connecting areas 66 of the chip 20 as well as to the complementary connecting areas of the conducting tracks to be contacted, e.g. 24a, 28d, in such a way that a simple and especially releasable contact connection is achieved. As can clearly be seen from the hatched areas of the spring contacts 62 in Fig. 4, the lower portions of these spring contacts 62 are metallized so as to actually permit an electric contact between the chip and the conducting track. Just as the metal-

lized areas of the polymeric body 12, the metallized spring contacts 62 can be produced by injection moulding from the polymer material which is metallizable by a wet-chemical process. In cases in which only a single polymer material is used, the spring contacts may also be rendered conductive making use of a shadow mask etc..

Another alternative of fastening the chip is shown in Fig. 5. The chip 20 is here turned over with regard to its orientation in Fig. 4 so that, making reference to Fig. 5, the connecting areas 66 of the bare chip 20 face downwards. These connecting areas 66 are placed onto bumps 68, whereupon the housing cover 42, which is provided with a pressure-exerting spring 70, is attached and pressed towards the polymeric body 12 until the snap connectors 44 snap into place.

Fig. 6, however, shows a further possibility of contacting the chip 20, the chip 20 being here connected by means of adhesive bumps 72. The adhesive forming said adhesive bumps 72 must, of course, be a conductive adhesive. The adhesive bumps can be applied to the polymeric body e.g. by means of the stamping technique, the dispensing technique or by means of a stencil printing technique.

In the electromechanical components according to the present invention, the chip 20 preferably fulfills the known electronic functions for use as an acceleration sensor, a rotary speed sensor, a microvalve, a micropump, a pressure sensor, a force sensor. Functions may e.g. be capacitance reading, temperature compensation and self-test functions.

Fig. 7 shows a top view of a detail of the interleaving electrode groups 100 of Fig. 1, the electrode fingers having, however, a wavelike shape. As can be seen in Fig. 7, the polymeric body is provided with wavelike electrode structures 100 so as to achieve a higher mechanical stability of thin mould walls during injection moulding.

From the statements made hereinbefore, it can be seen that by means of the geometrical design of the active part of the electromechanical component, i.e. in the case of acceleration sensors of the springs and the mass, by the selection of the materials in

question and by the optimization of the metal thicknesses, parameters can be achieved similar to those of known airbag sensors made of silicon. This applies especially to the basic capacitance, the sensitivity as a change of capacitance with applied acceleration, the natural frequency and the damping. In view of the fact that the properties of the electromechanical components according to the present invention are similar to those of silicon sensors, it is even possible to use electronic circuits which are, in principle, intended to be used with silicon, or at least circuits which are similar to the already existing circuits. Hence, a complete redesign would no longer be necessary on the electronic side.

Summarizing, it can be stated that an electromechanical component according to the present invention comprises movable elements, integrated conducting tracks and areas with metallized surfaces, the electromechanical components of polymer materials being preferably produced with the aid of a two- or a multi-component injection moulding technique and currentless chemical metallization. The essential advantages in comparison with electromechanical components made of silicon are the following ones:

- drastically reduced costs due to the simple production;
- the polymer bodies can be given an arbitrary shape so as to realize snap connections, pressure-exerting springs, alignment pins, guide holes, anchoring means, sealing means, ...;
- less sensitivity to contamination and ambient conditions in view of the fact that the size of the components can be adjusted to arbitrary dimensions; and
- arbitrary three-dimensional shaping instead of the two-dimensional surface treatment known in connection with silicon.

### CLAIMS

1. An electromechanical component comprising:  
  
a polymeric body including a mechanically active part and a frame; and  
  
a metal layer which covers the mechanically active part at least partially so as to mechanically stabilize the same,  
  
wherein an area of the polymeric body, which has the metal layer provided thereon, consists of a first polymer material which is adapted to be metallized in a wet-chemical process, and another area, which does not have a metal layer provided thereon, consists of a second polymer material which is not adapted to be metallized in a wet-chemical process.
2. An electromechanical component according to claim 1, wherein the mechanically active part includes a spring connecting the frame to a mass which moves when said spring bends; and  
  
wherein the metal layer completely encompasses the spring with the exception of the locations where said spring is connected to the frame and the mass.
3. An electromechanical component according to claim 1, wherein a further metal layer is additionally provided on a mechanically non-active part of the polymeric body, said further metal layer being used for conducting electric signals or for screening off electromagnetic disturbances.
4. An electromechanical component according to claim 1, wherein an additional area of the polymeric body, which has provided thereon the further metal layer, also consists of the first polymer material.

DET 34

5. An electromechanical component according to claim 4, wherein the polymeric body is provided with anchoring means used for interconnecting at least the mechanically active part consisting of the first polymer material and the part of the polymeric body consisting of the second polymer material such that these parts are in essentially positive engagement with one another.

6. An electromechanical component according to claim 1,

wherein the polymeric body is provided with an electrode structure comprising a first group of electrodes on the movable mass and a second group of electrodes on the fixed frame, said first and second groups being arranged in an interleaving mode of arrangement so as to act as a capacitive sensor a movement of the mass,

the further metal layer covering the first group of electrodes as well as the second group of electrodes at least partially, and said further metal layer being implemented such that the first group of electrodes is electrically insulated from the second group of electrodes by an area of the polymeric body having no metallization.

7. An electromechanical component according to claim 3, wherein the further metal layer is also provided with a connecting region including contact areas for an electronic circuit, a connecting plug and/or an SMD/soldered connection, said contact areas being electrically insulated from one another.
8. An electromechanical component according to claim 1, wherein the metal layer has a sandwich structure consisting of various metals, and/or is reinforced by electroplating.

9. An electromechanical component according to claim 1, comprising in addition:

a housing base made of polymer; and

a housing cover made of polymer,

AN 34



the polymeric body being arranged between the housing cover and the housing base.

10. An electromechanical component according to claim 9, wherein the polymeric body, the housing cover and the housing base are provided with snap connection means with the aid of which the polymeric body, the housing cover and the housing base are interconnected mechanically and/or electrically.
11. An electromechanical component according to claim 9, wherein alignment means are provided on the housing cover, the housing base and the polymeric body, so as to align the polymeric body with the housing base and the housing cover.
12. An electromechanical component according to claim 9, wherein a sealing means made of polymer is provided so as to encapsulate the electromechanical component, said sealing means being especially a seal which is formed integrally with the housing base, the housing cover and/or the polymeric body by injection moulding, or a separate sealing ring.
13. An electromechanical component according to claim 9, wherein the polymeric body and the housing base are formed integrally with one another.
14. An electromechanical component according to claim 7, comprising in addition:  
  
an electronic circuit for activating and/or evaluating the mechanically active part, the electronic circuit being connected to the contact areas in an electrically conductive manner by bonding wires, by solder means, by a conductive adhesive or by spring force-actuated contacts.
15. An electromechanical component according to claim 9, comprising in addition:  
  
an electronic circuit for activating and/or evaluating the mechanically active part, the

Art 34

electronic circuit being connected to the contact areas by at least one spring contact in an electrically conductive manner, and said spring contact being formed integrally with the housing cover or the housing base and having a metallized area extending from a connecting area of the electric circuit to a contact area on the polymeric body.

16. An electromechanical component according to claim 15, wherein the polymeric body is provided with a recess, the electronic circuit being placed in said recess.
17. An electromechanical component according to claim 1 implemented as an acceleration sensor, a rotary speed sensor, a microvalve, a micropump, a pressure sensor or a force sensor.
18. An electromechanical component according to claim 1, wherein one polymer material is selected from a group comprising Pd-doped LCP and undoped polyamide 66, wherein the second polymer material is undoped LCP, and wherein the metal layer and the further metal layer consist of copper, nickel, gold or of a combination of these materials.
19. An electromechanical component according to claim 1, wherein the mechanically active part of the polymeric body includes a metal body inserted in the polymer material so as to increase the mass.
20. An electromechanical component according to claim 1, wherein the mechanically active part of the polymeric body is provided with recesses so as to define spacers preventing the mechanically active part from sticking to the frame in the case of movement or contact.
21. A method for producing an electromechanical component comprising the steps of:

Art 34

forming a polymeric body including a mechanically active part and a frame, the step of forming the polymeric body comprising the following steps in an arbitrary sequence:

injection moulding a first portion of the polymeric body which is to be metallized, making use of a first polymer material which is adapted to be metallized in a wet-chemical process;

injection moulding a second portion of the polymeric body which is not to be metallized, making use of a second polymer material which is not adapted to be metallized in a wet-chemical process; and

forming a metal layer, which covers the mechanically active part at least partially so as to mechanically stabilize the same, by wet-chemical metallization in such a way that only the surfaces of the polymeric body consisting of the first polymer material are provided with a metal layer.

22. A method according to claim 21, wherein the step of forming the metal layer comprises vapour-phase coating making use of a shadow mask.

23. A method according to claim 21, wherein the step of forming the metal layer additionally comprises:

reinforcing the wet-chemically produced metal layer by electroplating.

24. A method according to claim 23, wherein the reinforcement by electroplating comprises the steps of:

fixing the mechanically active part of the polymeric body to the frame of the polymeric body making use of an auxiliary structure;

applying a potential to a fixed part of the polymeric body;

Art 34

depositing a metal on the movable part and the mechanically active part; and,

after the step of reinforcing the metal layer by electroplating, removing the auxiliary structure.

25. A method according to claim 21, comprising the steps of

forming the polymeric body such that it is provided with snap connections;

injection moulding in addition a polymer cover and a polymer base of the housing which are equipped with snap connections as well; and

pressing the polymeric body, the polymer cover and the housing base together until the snap connections have snapped into place.

26. A method according to claim 25, wherein the polymeric body is not provided with any snap connections and wherein the polymer cover and the housing base are interconnected by ultrasonic welding or laser welding.

27. A method according to claim 21, wherein also the housing base is formed during the step of forming the polymeric body so that the polymeric body and the housing base are formed integrally with one another.

28. A method according to claim 26, wherein the step of forming comprises the following steps:

injection embossing (injection stamping) or hot embossing (hot stamping) a polymer starting material so as to obtain an embossed element (stamped element) including the mechanically active part as well as geometrically fine structures of the frame; and

encompassing the embossed element with polymer material by means of injection

ART 34

moulding so as to obtain the polymeric body.

29. A method according to claim 21, wherein the step of forming comprises the following steps:

injection moulding an initial body of polymer material;

injection embossing or hot embossing said initial body of polymer material so as to obtain the polymeric body in such a way that the mechanically active part as well as geometrically fine structures of the frame are defined by injection embossing or hot embossing; and

encompassing the embossed element with polymer material by means of injection moulding so as to obtain the polymeric body.

30. A method according to claim 21, comprising in addition the following step:

equipping the electromechanical component with an electronic circuit by glueing making use of a conductive adhesive, by wire bonding, by soldering or by constant application of a mechanical pressure to the electronic circuit, so as to guarantee a mechanical as well as an electrical connection between the polymeric body and the electronic circuit.

31. A method according to claim 21, wherein the following steps are carried out prior to the metallization:

cleaning the polymeric body;

tempering the polymeric body; and

sensitizing the surface of the polymeric body.

ART 34

32. A method according to claim 31, wherein the step of sensitizing the surface is caused by a surface reaction comprising mild etching of the surface or causing the surface to swell or subjecting the surface to a plasma treatment and seeding it with suitable seeds so as to obtain a metallization.

33. A method according to claim 21, wherein the step of forming the polymeric body comprises the following steps:

providing a metal body;

encompassing said metal body with polymer material by injection moulding so as to form the polymeric body in such a way that the mechanically active part of the polymeric body includes the metal body.

34. A method according to claim 21, wherein an electrode structure is defined by the metal layer, the capacitance of said electrode structure being increased by reinforcing the metal layer thickness and by the resultant change in the electrode distance.

35. A method according to claim 21, wherein the step of forming the polymeric body includes the following step:

forming recesses on the mechanically active part or on the frame so as to define spacers preventing the mechanically active part from sticking to the frame in the case of movement or contact.

36. A method according to claim 21, wherein the polymeric body is provided with electrode structures having a wavelike shape so as to achieve a higher mechanical stability of thin mould walls during injection moulding.

Art 34

## ELECTROMECHANICAL COMPONENT AND METHOD FOR PRODUCING THE SAME

### **Abstract**

An electromechanical component comprises a polymeric body including a mechanically active part and a frame, and a metal layer which covers the mechanically active part at least partially so as to mechanically stabilize the same, an area of the polymeric body, which has the metal layer provided thereon, consisting of a first polymer material which is adapted to be metallized in a wet-chemical process, and another area, which does not have a metal layer provided thereon, consisting of a second polymer material which is not adapted to be metallized in a wet-chemical process. The electromechanical component can be an acceleration sensor, a rotary speed sensor, a microvalve, a micro-pump, a pressure sensor, or a force sensor. Production of said electromechanical component incurs drastically reduced costs compared to electromechanical components produced using silicon-based technology because simple injection-moulding and/or embossing processes, instead of the complicated silicon-based technology, can be used for producing said electromechanical component.





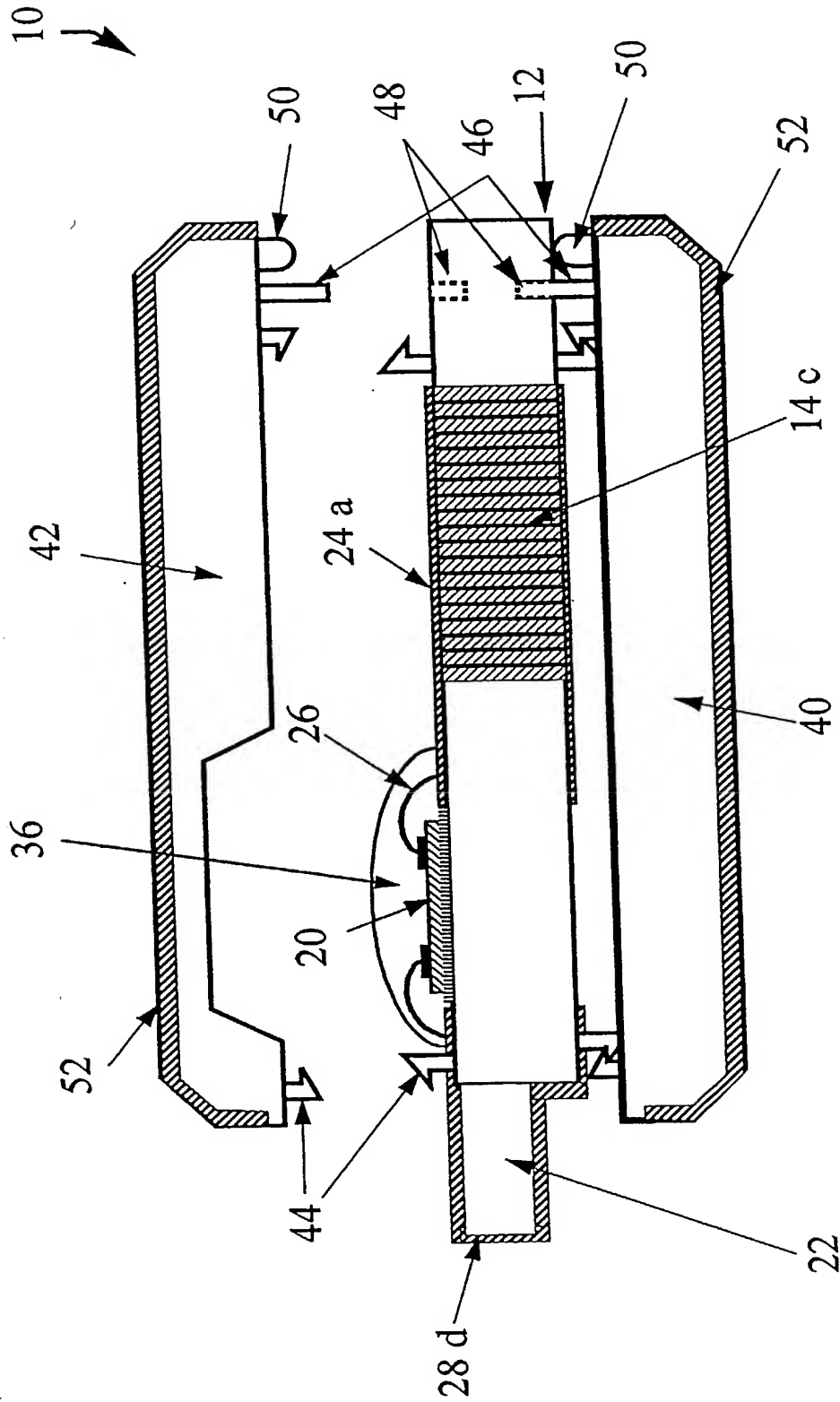


Fig. 2

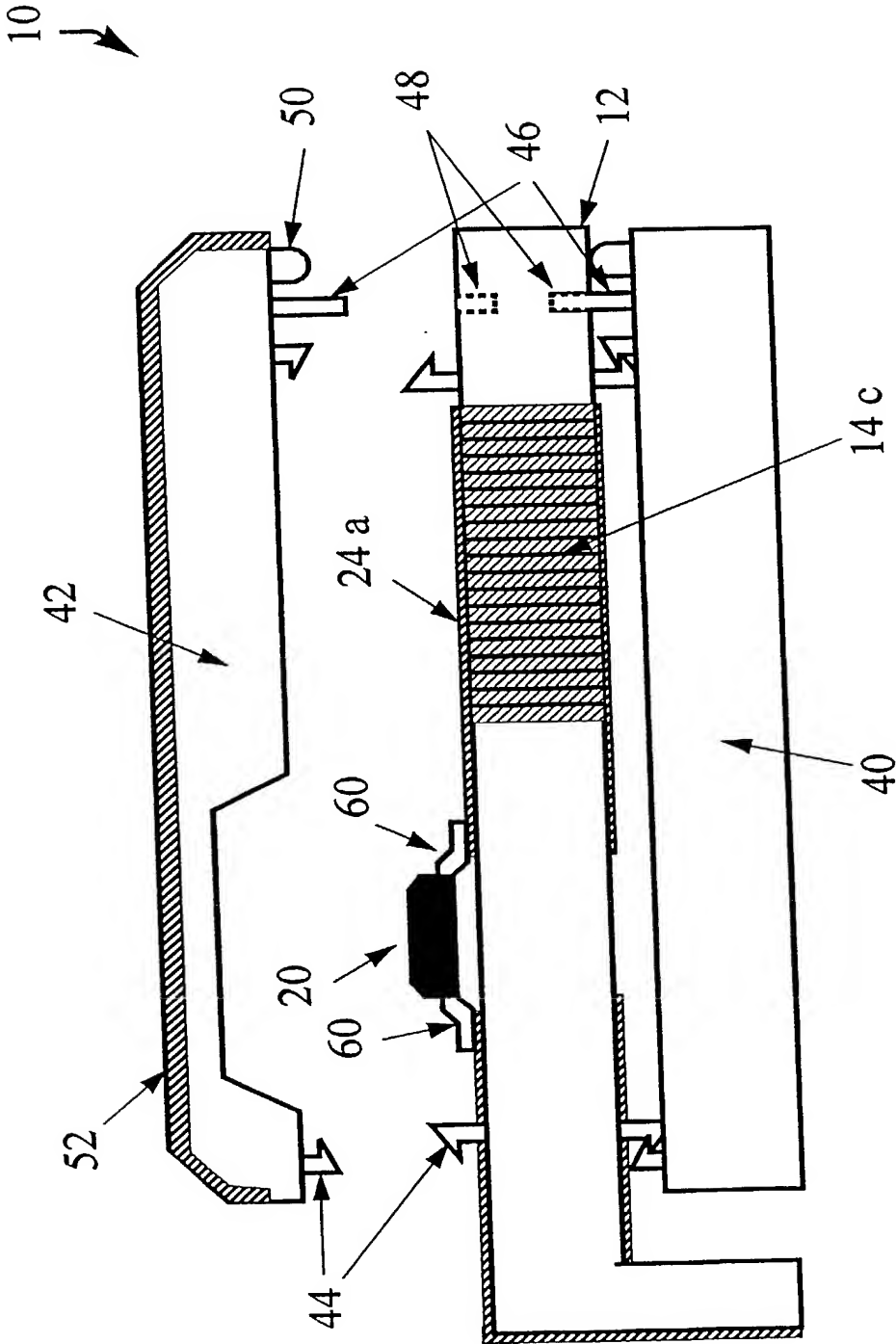


Fig. 3

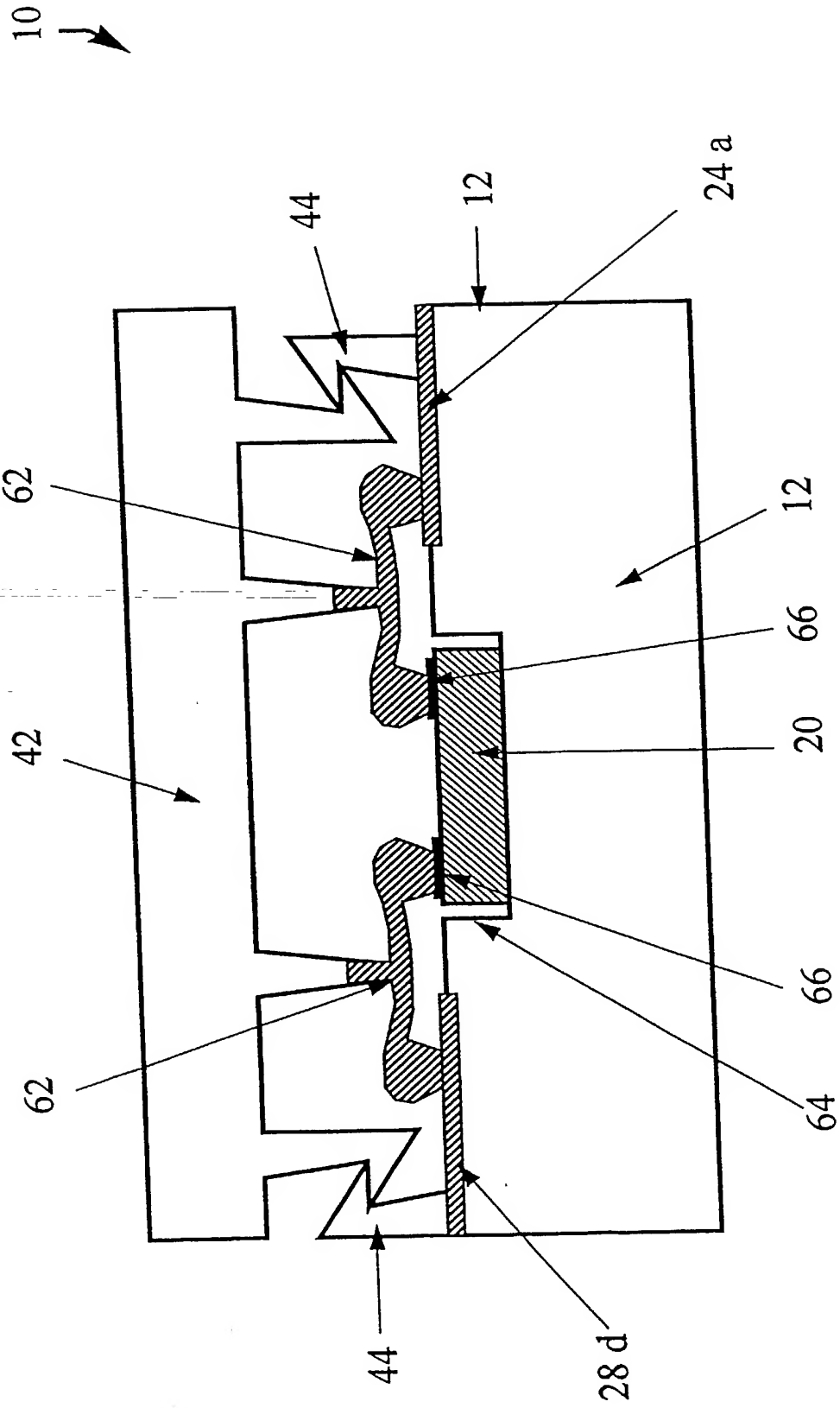


Fig. 4

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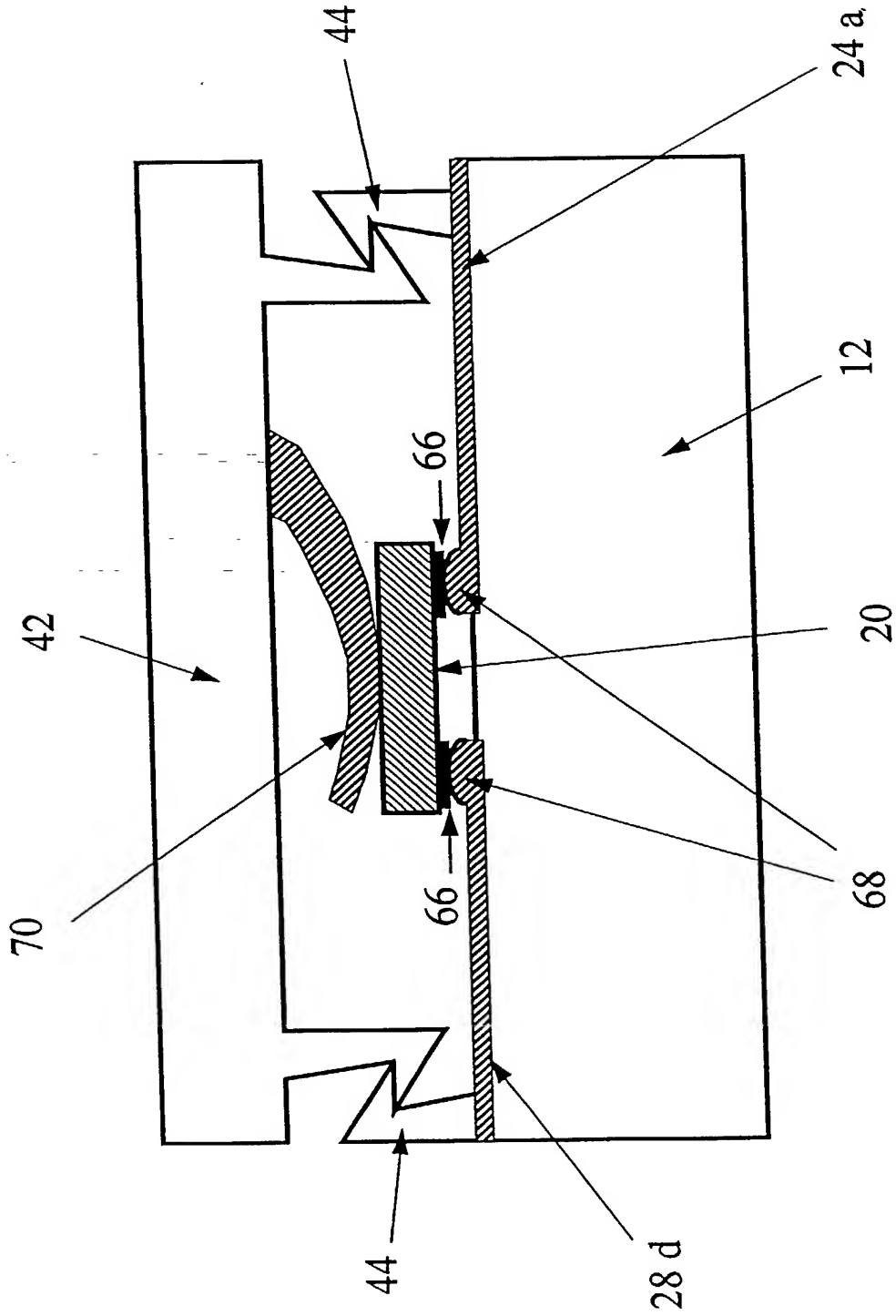


Fig. 5

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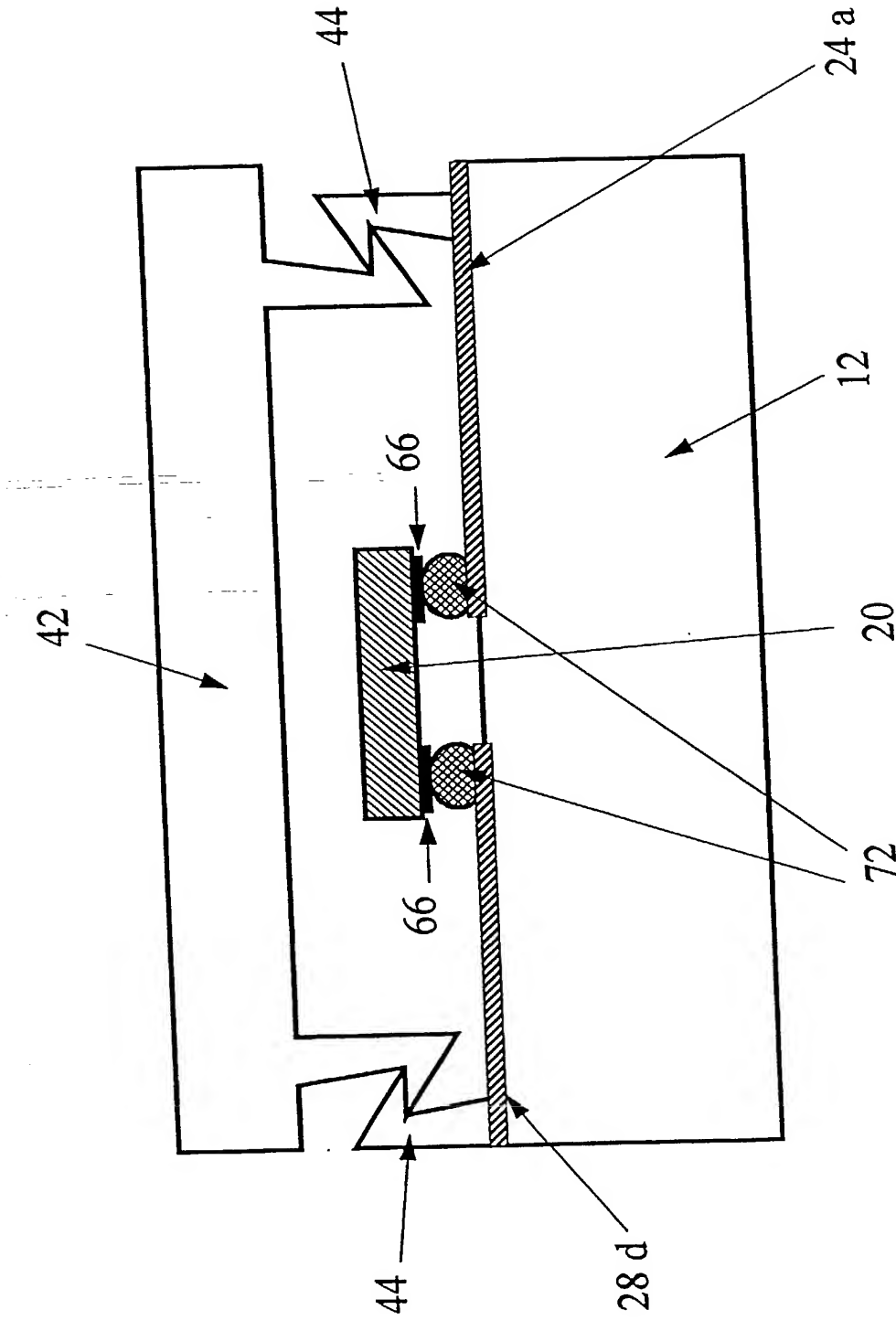


Fig. 6

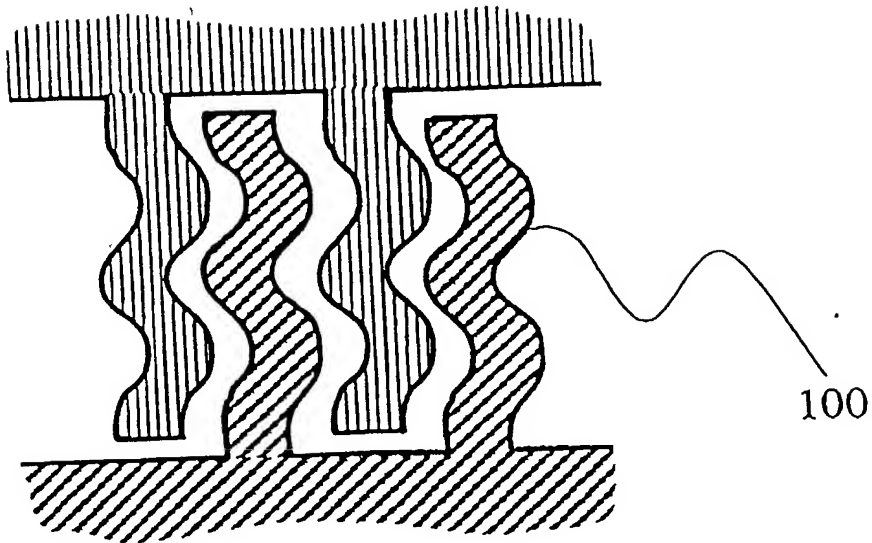


Fig. 7

Practitioner's Docket No. 13189.146US**PATENT**

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**COMBINED DECLARATION AND POWER OF ATTORNEY****(ORIGINAL, DESIGN, NATIONAL STAGE OF PCT, SUPPLEMENTAL, DIVISIONAL,  
CONTINUATION, OR C-I-P)**

---

As a below named inventor, I hereby declare that:

**TYPE OF DECLARATION**

This declaration is for a national stage of PCT application.

**INVENTORSHIP IDENTIFICATION**

My residence, post office address and citizenship are as stated below, next to my name. I believe that I am the original, first and sole inventor of the subject matter that is claimed, and for which a patent is sought on the invention entitled:

**TITLE OF INVENTION**ELECTROMECHANICAL COMPONENT AND METHOD FOR PRODUCING THE SAME

---

**SPECIFICATION IDENTIFICATION**

The specification was described and claimed in PCT International Application No. PCT/EP00/09814  
filed on October 6, 2000

**ACKNOWLEDGMENT OF REVIEW OF PAPERS AND DUTY OF CANDOR**

I hereby state that I have reviewed and understand the contents of the above-identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose information, which is material to patentability as defined in 37, Code of Federal Regulations, Section 1.56, and which is material to the examination of this application, namely, information where there is a substantial likelihood that a reasonable Examiner would consider it important in deciding whether to allow the application to issue as a patent.

**PRIORITY CLAIM (35 U.S.C. Section 119(a)-(d))**

I hereby claim foreign priority benefits under Title 35, United States Code, Section 119(a)-(d) of any foreign application(s) for patent or inventor's certificate or of any PCT international application(s) designating at least one country other than the United States of America listed below and have also identified below any foreign application(s) for patent or inventor's certificate or any PCT international application(s) designating at least one country other than the United States of America filed by me on the same subject matter having a filing date before that of the application(s) of which priority is claimed.

Such applications have been filed as follows.

**PRIOR PCT APPLICATION(S) FILED WITHIN 12 MONTHS  
(6 MONTHS FOR DESIGN) PRIOR TO THIS APPLICATION  
AND ANY PRIORITY CLAIMS UNDER 35 U.S.C. SECTION 119(a)-(d)**

INDICATE IF PCT	APPLICATION NUMBER	DATE OF FILING DAY, MONTH, YEAR	PRIORITY CLAIMED UNDER 35 U.S.C. SECTION 119
PCT	PCT/EP00/09814	06/October/2000	yes

**PRIOR FOREIGN APPLICATION(S) FILED WITHIN 12 MONTHS  
(6 MONTHS FOR DESIGN) PRIOR TO THIS APPLICATION  
AND ANY PRIORITY CLAIMS UNDER 35 U.S.C. SECTION 119(a)-(d)**

COUNTRY	APPLICATION NUMBER	DATE OF FILING DAY, MONTH, YEAR	PRIORITY CLAIMED UNDER 35 U.S.C. SECTION 119
DE	199 48 613.1	08/October/1999	yes

**POWER OF ATTORNEY**

I hereby appoint the practitioner(s) associated with the Customer Number provided below to prosecute this application and to transact all business in the Patent and Trademark Office connected therewith.

**Customer No. 24283**

SEND CORRESPONDENCE TO  
**Customer No. 24283**

DIRECT TELEPHONE CALLS TO:  
Carl A. Forest  
303-379-1114

**DECLARATION**

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.



**SIGNATURE(S)**

100

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